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INDUSTRIAL STREAM POLLUTION ABATEMENT

By L. L. Hedgepeth

SANITARY ENGINEERING DIVISION

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PAPERS

INDUSTRIAL STREAM POLLUTION ABATEMENT

By L. L. Hedgepeth[1]

Synopsis

In the abatement of industrial pollution of streams a program based on forthrightness, tact, good will, and good faith will be found profitable. This view is derived from the writer's experience on stream sanitation while in the employ of industry and of the public. The industrial waste problem is so complex as to defy standardization. Each case requires informed handling, and actual abatement may best be secured through study of each individual case, rather than the issuance of blanket orders.

The writer's work on major pollution sources in Virginia is cited in some detail in support of his regulatory thesis. The problems of a pulp mill, a wool scouring plant, and a rayon finishing and dyeing plant are used as examples. Also outlined is his method of attack of the complex problem presented by the concentration of industrial and municipal pollution on the South River at Waynesboro, Va.

Tasks of considerable size lie ahead of stream sanitarians in their work for the protection of presently clean streams and the restoration of those now polluted. Some of those awaiting performance are of sobering magnitude. Many, and probably the great majority, will respond to a sound technical approach. On others there is much to learn before success may be expected.

This paper relates principally to the industrial waste phase of stream pollution. Essentially it is an outline of one approach to the solution of this problem —by simplification and working together. It has been found that the employment of utter practicability in the interpretation of law and data, and in the determination of practicable goals of attainment, is a profitable method of attack on this problem.

A program based on forthrightness, tact, good will, and good faith is infinite in its possibilities. Successfully prosecuted, it discourages the development of widely divergent and incompatible views. By keeping discussions on a

Note.—Written comments are invited for publication; the last discussion should be submitted by February 1, 1951.

[1] Staff Technical Consultant, Calco Chemical Div., Am. Cyanamid Co., Bound Brook, N. J.; formerly Executive Secy., Virginia State Water Control Board, Richmond, Va., through December, 1948.

practical level, it also discourages wishful thinking by government and industry and thus avoids much misunderstanding.

These concepts have developed as a result of the observation that the actual accomplishment of stream pollution abatement is primarily a "selling" job. Principles of human persuasion have been applied with gratifying results to the stream pollution problems of the Commonwealth of Virginia which in 1946 started its first comprehensive effort[2] toward protection of presently clean streams and the restoration of those now fouled by sanitary sewage and industrial wastes.

Essentially, the Virginia State Water Control Law is a regulatory approach to the stream pollution problem. All discharges, whether new or old, are placed under individual permit control. In cases of established pollution, the owner may be required to reduce the pollution from time to time under threat of revocation of the permit. In cases of new or increased pollution, the permit is predicated on treatment of the wastes or sewage so as to render each one harmless to the receiving stream. Discharges without permits are forbidden. Penalties are provided.

According to the records of the Virginia State Water Control Board (VWCB), 226 permits to discharge sewage, mostly untreated, were issued in Virginia during the two years ending June 30, 1948 (meeting minute 3, VWCB, November 10, 1948), and 203 permits were issued for established industrial wastes. The latter may be harmless, or polluting, or devastating, depending on the case. Collectively they are massive and, for the most part, destructive in their effects. For example, the following conditions exist: A pulp mill with a B.O.D. (biochemical oxygen demand) load equal to 250,000 people; a rayon plant whose toxic wastes have destroyed virtually all marine life for 60 miles downstream; a chemical plant with wastes equaling 60,000 people in B.O.D. loading; another chemical plant with 110 tons of H_2SO_4 sewered daily; another plant discharging, daily, 2 million gal of waste brine containing 14% solids by weight; and an oil plant, one of several in the neighborhood, whose wastes equal 72,000 people.

These and other crushing loads issue from plants which are important elements in Virginia's economy. The problem is to reduce this pollution and to prevent new loading, without upsetting the state's manufacturing balance. It is an elementary fact that people must have an opportunity to work in order that they may be self-supporting. When industrial pollution abatement interferes with employment, stream restoration becomes most difficult.

On this problem, Mr. Justice Archibald C. Buchanan of the Virginia Supreme Court of Appeals has stated in part:[3]

> "The history of the Water Control Law and the terms of that law leave little room for doubt or speculation as to how its purposes are to be attained. Some waters of the State are clean, others are polluted. Pollution is a recognized evil and is against public policy when caused by one not having a certificate issued by the Board. * * * The end desired is to keep the clean waters clean and to reduce the pollution in the unclean waters. Some of this

[2] State Water Control Law, Code of Virginia, Richmond, Va., 1946, Chapter 63-b.

[3] American Cyanamid Company Versus Commonwealth of Virginia, Virginia Supreme Court of Appeals, Richmond, Va., June 14, 1948, record No. 3368.

pollution comes from industrial waste, discharged by industries invited into the State and furnishing employment to some of its people. The problem is to be dealt with so as to give fair treatment to the industries, to its employees and to the public. That requires a measuring and balancing of the interests involved. Some waters should be kept pure. A measure of pollution in others is necessary. Not all pollution can be abruptly stopped. On the agreed facts here, for example, this industry would have to shut down if immediately required to cease discharging its acid waste into the river. The aesthetic and recreational features involved in the pollution problem are important, but the opportunity to make a living may be even more so."

Waste disposal should be regulated by control measures which are practical. Sound law, impartially enforced, is essential in placing stream pollution control on a "must" basis. Once such a law is provided, and all individuals and agencies are placed under its control, progress is best and most easily accomplished through a good technical analysis of each case and a determination of goals to suit the local needs. This opinion is based on the facts that actual abatement is secured by working on the individual cases, that compulsory action may be directed only against the individual party, and that, if the requirements for any given discharge are selected to suit that discharge, lessened resistance from the owners may be expected.

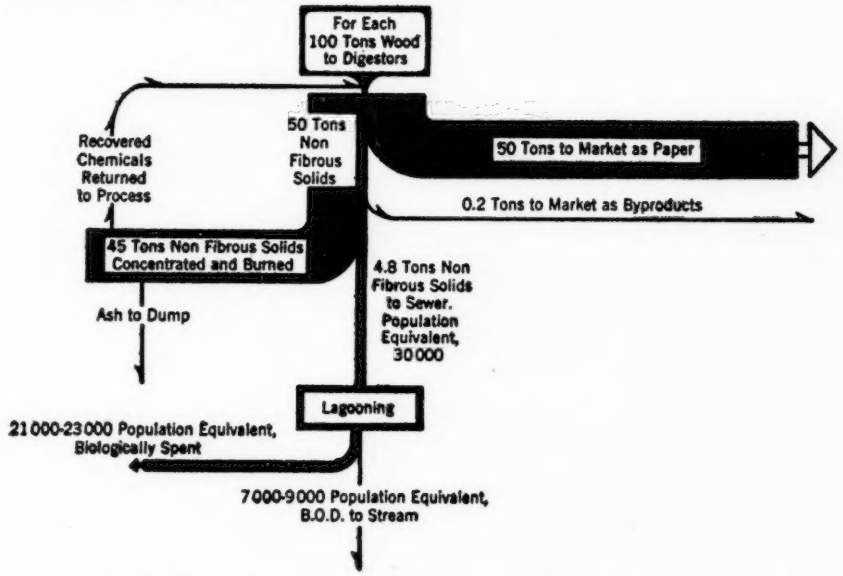

FIG. 1.—SIMPLIFIED ILLUSTRATION OF A STREAM POLLUTION PROBLEM AT A SOUTHERN PULP MILL

To illustrate the practical individual approach, the waste water problems of a pulp mill, a woolen mill, and a rayon finishing and dyeing plant have been selected. All these are large plants with significant pollution problems. All are of considerable economic importance to their communities. The management of each has been partly or entirely successful in efforts to find a workable answer to the problem.

Fig. 1 depicts a problem (meeting minute 17, VWCB, June 3 and 4, 1948), involving a typical pulp mill which cooks nonfibrous matter from the wood by the use of a liquor consisting essentially of a mixture of caustic soda and sulfides. Since the soda and sulfur for the cooking liquor make-up are derived from sodium sulfate, this type of mill is also called a sulfate mill.

It is sometimes stated that this type of mill does not pollute streams because the cooking liquor is reprocessed for the recovery of its soda values. This is not true since only the cooking liquor and the stronger washing waters are customarily recovered. The stream pollution load from the remainder of the washing waters may be quite heavy. Examination of Fig. 1 shows that about 10% of the nonfibrous refuse (about 5% of the weight of pulp wood) and also about 10% of the chemicals used in the cooking process are sewered.

In the mill whose problem is depicted by this graph, 500 tons, more or less, of wood is normally pulped daily to produce 250 tons of paper. The result is a daily loss of 25 tons, more or less, of nonfibrous wood solids borne to the sewer in 8 mgd of water. In addition to its odor, color, and resistance to assimilation, this waste has a B.O.D. of 150,000, population equivalent.

The solution to this problem, provided by the owner after considerable voluntary study, consisted of: First, eliminating unnecessary wastes at their source; and, second, supplying aging and biological treatment in very large lagoons for all the sewered wastes. When first reported, these lagoons were reducing the 5-day B.O.D. about 22%.[4] Today they are yielding an over-all reduction of from 70% to 75% in the 5-day B.O.D. load to the stream and the effluent is otherwise less troublesome than before (meeting minute 17, VWCB, June 3 and 4, 1948).

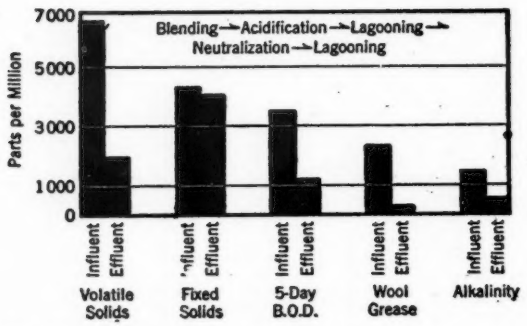

FIG. 2.—RESULTS OF EMERGENCY TREATMENT FOR WOOL-SCOURING, FINISHING, AND DYEING WASTES

Thus, the owner has greatly improved the stream; and, except during drought conditions, there is not much of a stream pollution problem remaining below this mill. Additional reductions are now being sought through a change in pulp washing equipment designed to reduce further the sewered wastes.

Fig. 2 illustrates what was done with an "unsolvable" problem (meeting minute 15, VWCB, February 4, 1947; meeting minute 20, VWCB, May 19–20, 1947; and meeting minute 13, VWCB, October 1–2, 1947). A conflict was probable between the "no new pollution" requirements of the law and the obstinate fact that a year or more would be required to design and construct a treatment plant to remove the heavy content of wool grease from these wastes,

[4] "Ponding of Sulfate Paper Mill Wastes," by Stuart C. Crawford, *Sewage Works Journal*, July, 1947, p. 621.

to remove the sludge and scum, to provide an effluent pH-value within the range of from 6.0 to 8.0, and to reduce the flowing load B.O.D. to the level of safety for the receiving stream.

Officially a deadlock was imminent. The owner felt that he should be allowed to run his own manufacturing plant, and that time must be granted to build the treatment plant. The authorities felt that it could not be granted under the law. Therefore, it was undertaken unofficially and cooperatively with the owner and his engineers. The engineers risked their professional reputation on an emergency treatment plant employing makeshift apparatus and lagoons; the owner risked his money. Providence helped considerably by producing higher than normal river flows for the next 3 months, thus avoiding stream damage during the no treatment period.

The treatment provided consisted essentially of blending of the several wastes, then acidification, then lagoon storage for 2 weeks, and finally neutralization followed by 3 weeks of lagooning before discharge of the supernatant into the river (see Fig. 2).

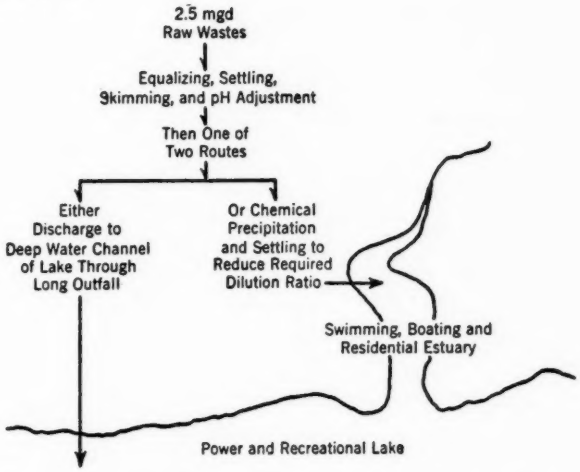

FIG. 3.—PROPOSED DISPOSAL METHODS FOR RAYON—FINISHING AND DYEING WASTES

For more than a year this emergency plant retained substantially all the wool grease, adjusted the pH-value, removed the sludge and scum, and otherwise prevented stream damage. It also provided the owner time to build a proper plant, made it possible for more than 2,000 people to remain at work, gave the owner use of his manufacturing property, and prevented the law from compounding an absurdity.

Fig. 3 is an illustration of the alternate solutions devised for a rayon finishing and dyeing company which had purchased a property near a recreational and power lake and then had sought approval for the discharge of the colored waste waters into this normally clear lake (meeting minute 8, VWCB, February 10, 1948; and meeting minute 9, VWCB, September 14, 1948). Fortunately, partial operations for several months provided a period of valuable experience

with existing treatment equipment for determining how much of the color could be removed by chemical precipitation and settling. The conclusion was that no combinations of iron or alum coagulants and chlorine would reduce the color so that the full flow of wastes could be absorbed during drought conditions without an esthetic nuisance in that arm of the lake nearest the plant—because at least 300 to 1 dilution with clear lake water was required for satisfactory absorption of the treated wastes being produced by this plant during the study period.

Furthermore, if the raw wastes were equalized, settled, skimmed, and kept between pH-values of from 6.0 to 8.0, they could be disposed by dilution, provided a 900 to 1 dilution ratio was available. Since this ratio was available in the lake proper, but not in the near-by arm, the owner elected to make the additional capital investment for the long pipe line and thus avoid the threat of a slowdown or shutdown of the dyehouse in dry weather.

This case has been selected because of the color problem. For example, 400 ppm of residual color has been proposed as a maximum standard for industrial waste effluents.[5] In the writer's opinion, such a standard will be unenforceable. Some of these dye wastes have been found to be totally resistant to biological treatment and to respond reluctantly to chemical treatment, even when massive doses of coagulants and bleaching agents are applied. Experience strongly indicates that there is no maximum color standard that can be enforced on dyeing and finishing plants and that they should always be located on large streams where high dilutions are available. Given such locations it appears proper and reasonable to limit treatment to settling, skimming, equalizing, and pH-control before dilution. A big muddy river is the ideal location for a plant producing highly colored wastes.

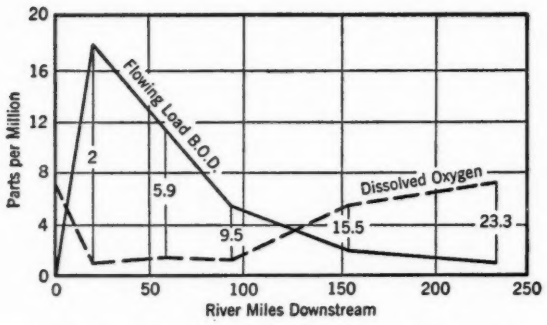

FIG. 4.—OXYGEN BALANCE OF SOUTH RIVER, DOWNSTREAM FROM WAYNESBORO, VA. (AVERAGES FOR JULY, AUGUST, AND SEPTEMBER, 1948)

There is also a workable approach to the group problem involving industrial wastes and sanitary sewage. An example is the stream pollution problem in 24 miles of the South River between Waynesboro and Port Republic, Va., where the South River joins the Middle and North rivers to form the South Fork of the Shenandoah River.[6]

Upstream from Waynesboro this stream is relatively clean and normal. On its 2 miles of flow through the city, it receives the wastes from a large rayon finishing and dyeing plant, a huge cellulose acetate plant, and the city sewage. Below the city, the stream's oxygen drops in summer to from 1 ppm to 2 ppm and

[5] "Industrial Waste Requirements," Maryland Water Pollution Control Comm., Baltimore, Md., 1948, regulation IV.

[6] "Final Report South River Study Committee," Records, Virginia State Water Control Board, Richmond, Va., November 4, 1948.

at times to zero. The coliform organism population rises to astronomical values. The stream is dark and scum laden. The fishes try to reestablish themselves when cool weather and higher flows restore the oxygen. They are later killed by the recurrence of oxygen depletion and float downstream by the hundreds. Considerable ill feeling prevailed because of the condition of this stream. The problem was to separate fact from fancy by providing a simple and dependable analysis of this pollution for the city and its industries as well as for the VWCB.

Obviously several sources of pollution were jointly responsible; but it was not apparent for what kind of pollution they were severally responsible—and for how much of the total pollution. The VWCB consulted those involved, formed a cooperative task force, distributed the work load, and studied the stream for 3 months during its most polluted season. Then the collected data were reviewed, conclusions of fact were drawn as a basis for later work, and, its task having been completed, the task force committee was dissolved.

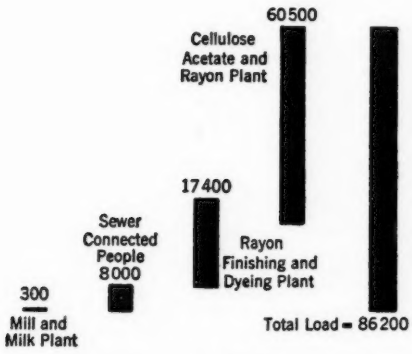

FIG. 5.—DISTRIBUTION OF B.O.D. LOAD (POPULATION EQUIVALENTS) FROM SANITARY SEWAGE AND INDUSTRIAL WASTES—JULY, AUGUST, AND SEPTEMBER, 1948; SOUTH RIVER BELOW WAYNESBORO, VA.

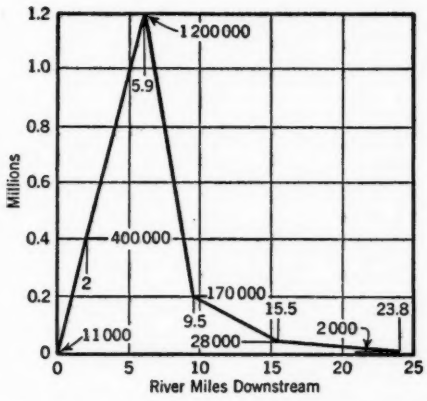

FIG. 6.—MOST PROBABLE NUMBERS OF COLIFORM GROUP DURING JULY, AUGUST, AND SEPTEMBER 1948; SOUTH RIVER BELOW WAYNESBORO, VA.

The 3-month average of the oxygen balance of the 24 miles, as reported by the South River Cooperative committee, is shown in Fig. 4. The river is in foul condition for about 10 miles; but beyond that point its recovery is quite rapid, being well advanced at mile 15.5 and substantially complete at mile 23.8. The stream appears to make a complete recovery below mile 23.8 and no latent harmful effects have been noted downstream from this pollution. This opinion is based on some spot checks by biologists and on a knowledge of the nature of the pollutants upstream.

Distribution of responsibility for this heavy B.O.D. loading is shown in Fig. 5. The data were derived from samples from each principal industrial sewer composited over 24 hours on each sampling day during the 3-month study. The principle involved is that the B.O.D. loading reduction problem is primarily industrial.

The rise and fall of the coliform group population are shown in Fig. 6. Although Fig. 5 shows that the city is responsible for only about 7% of the B.O.D. loading, it obviously is responsible for substantially all the sewage bacteria phase of the stream pollution. The principle involved is that treatment of sanitary sewage is essential to the restoration of the health of this stream.

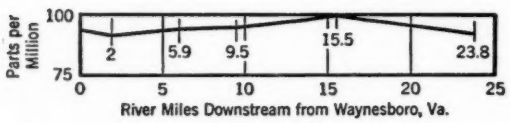

FIG. 7.—ALKALINITY VARIATIONS, DURING JULY, AUGUST, AND SEPTEMBER, 1948; SOUTH RIVER BELOW WAYNESBORO, VA.

Fig. 7 shows the alkalinity variations. Since the only significant changes occurred downstream, they appeared to be caused by downstream tributaries. In any case, the effect of the several pollutional discharges in Waynesboro was negligible on the alkalinity. This finding has exploded a popular belief that the fish were being killed by acid from the chemical plants. Similarly, the pH-variations at all stations were within the range covering normal biological activity and, therefore, were considered to be normal.

The average apparent color was increased from 17 ppm upstream to 30 ppm downstream. This increase was considered to be without practical significance. Thus, the principal phase of the dyeing and finishing plant problem is the B.O.D. load. Although there is hope of reducing the B.O.D., nothing can be done about the dye color except to decrease it at its source and then to dispose of the remainder by equalizing and by diluting the stream.

Collectively, Figs. 4 to 7 provide some badly needed information. Behind them is a story of good will, good faith, and much teamwork of which Waynesboro government, its industries, and the staff of the VWCB are quite proud. Fact has been separated from fancy—a considerable accomplishment in this field of conflicting interests.

CONCLUSION

In 1946 the writer proposed a rationalization of the industrial waste problem,[7] based on the premise that the stream pollution abatement program must be made attainable by industry if success were to be expected.

It is interesting to review this reasoning by examining the results of its application to a specific program. Some of the successes of this approach have been discussed. Its failures (and there have been several) have resulted from the refusal of angry and powerful groups to accept this scientific and cooperative approach as more suitable than the mandatory actions which they advocate.

On the "plus side of the ledger," manufacturing plant design, process control, waste treatment, and stream studies have gone hand in hand in progressive plants. This action by industry is most profitable and should yield great reductions in industrial pollution.

A case in point involves a pharmaceutical plant where, by correlation of the efforts of plant designers, process control men, and waste supervisors, management has internally reduced the B.O.D. load from a 66,000 population equiva-

[7] "Industrial Use of Streams," by L. L. Hedgepeth, *Journal*, A.W.W.A., June, 1947, p. 532.

lent in early 1947 to a 20,000 population equivalent in late 1948 (meeting minute 10, VWCB, December 6, 1948). In addition to this load reduction, these process control measures have so simplified the disposal problem that primary treatment is all that is now needed for this effluent.

Earnest and powerful forces in industry are at work on this problem. Its complexities are apparent. No two plants are alike. No two area or basin problems are the same. A program of considerable flexibility is needed if industrial stream pollution is to be corrected. Open minds and intellectual honesty will be needed.

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